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A Revitalized Perspective on Rebound:

*Several Observations in Light of New Data**

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Energy Efficiency and the Rebound Effect
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*** In the spirit and tradition of Nobel Laureate and former Caltech physicist Richard Feynman, in his 1959 visionary talk, "There's Plenty of Room at the Bottom." See, http://www.its.caltech.edu/~feynman/plenty.html.**

Two Insights

We shape the world by the questions we ask

Physicist John Wheeler

The most exciting phrase to hear in science, the one that heralds new discoveries, is not 'Eureka!' (I found it!) but 'That's funny…'

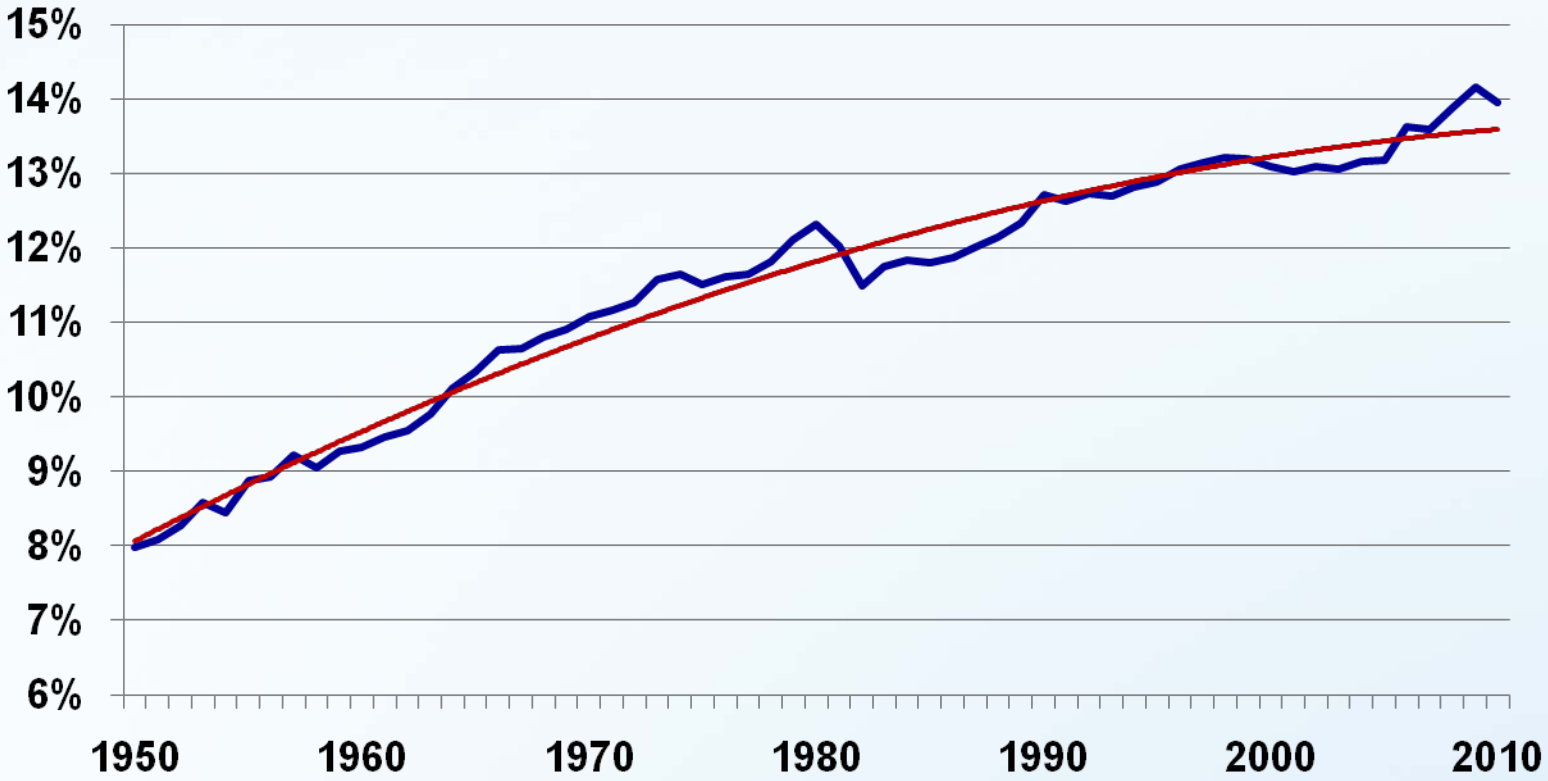
Isaac Azimov

With These Opening Observations

- The past is consistent with many, many different futures – depending on the choices we have yet to make.
- The economy requires not energy, but “used energy” to transform matter into useful work and the desired array of goods and services.
- A full investigation into rebound requires much more than the standard neoclassical economic framework; it also requires an understanding of the full range of behaviors motivated by more than prices, and it requires a digging into the full costs of energy services as well as an improved understanding of industrial ecology.
- Rebound is a badly named concept. Energy efficiency reduces the cost of energy services and drives larger economic productivity. This does not mandate rebound, but provides new opportunities and choices.
- We have never really tried to promote energy efficiency – at scale and over a persistent period of time.

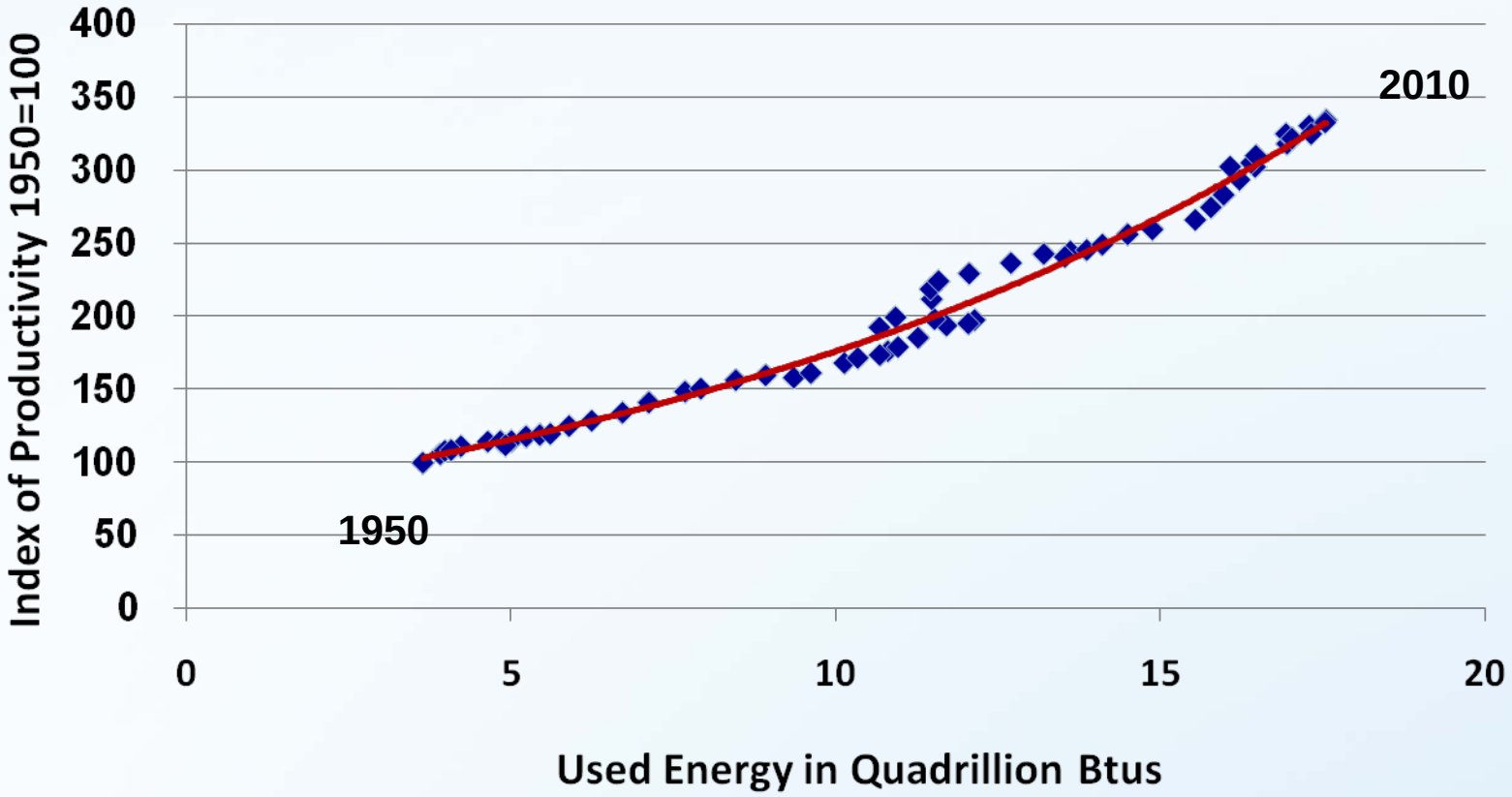
Conversion Efficiency

Primary Energy to Used Energy (and Useful Work)



Note: Here energy efficiency refers to the conversion of total primary energy to used energy.
Source: Bob *Ayres and Benjamin Warr 2009 with data updates from 2005 to 2010 by Laitner.*

U.S. Productivity as Function of Used Energy (1950-2010)



Source: Bob *Ayres and Benjamin Warr 2009 with data updates from 2005 to 2010 by Laitner*

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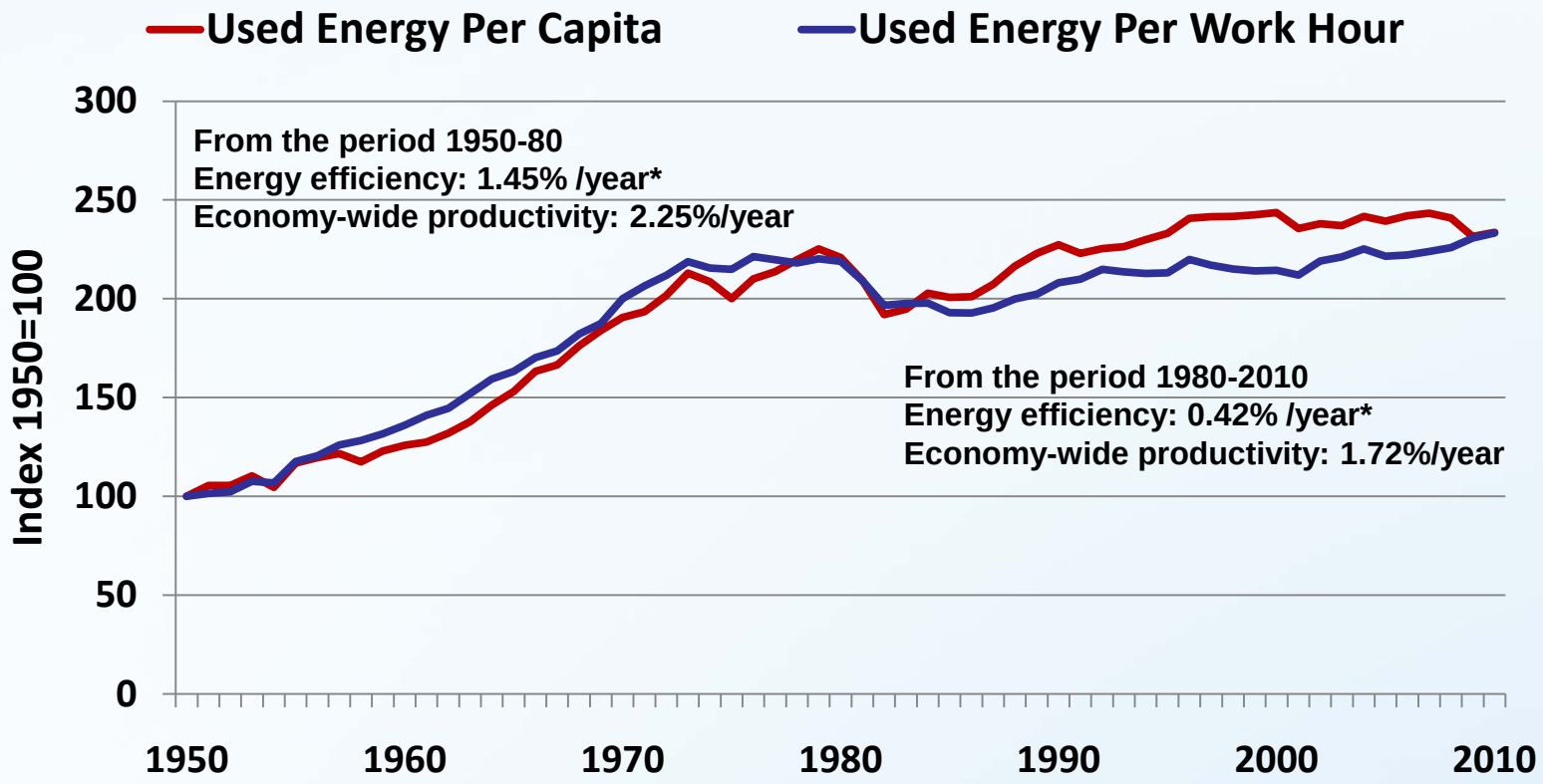
Emerging Insights in the Critical Role of "Used Energy" to Enhance Productivity



*Here energy efficiency refers to the conversion of total primary energy to used energy
Source: Laitner 2011 (forthcoming).

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U.S. Total Energy, Used Energy, and GDP

Year	GDP (Billion $2005)	Used Energy* (Quads)	Wasted Energy (Quads)	Total Energy (Quads)	Total Exergy (Quads)	Energy Efficiency	Exergy Efficiency
1900 Actual	431	0.4	9.2	9.6	14.8	3.8%	2.5%
1950 Actual	2,006	3.6	31.0	34.6	45.6	10.5%	8.0%
1980 Actual	5,839	12.0	66.1	78.1	97.7	15.4%	12.3%
2010 Preliminary	13,221	17.3	80.6	97.9	125.6	17.7%	13.8%
2030 AEO 2011	22,731	29.7	81.2	110.9	142.4	26.8%	20.9%
2030 More Likely	21,245	27.8	76.0	103.8	133.2	26.8%	20.9%
2030 High Efficiency	22,968	30.1	62.4	92.5	118.7	32.5%	25.4%

Source: Preliminary data based on Ayres and Warr 2009, AEO 2011, and author calculations.
*Note: Used energy creates “useful work” that transforms matter into goods and services.

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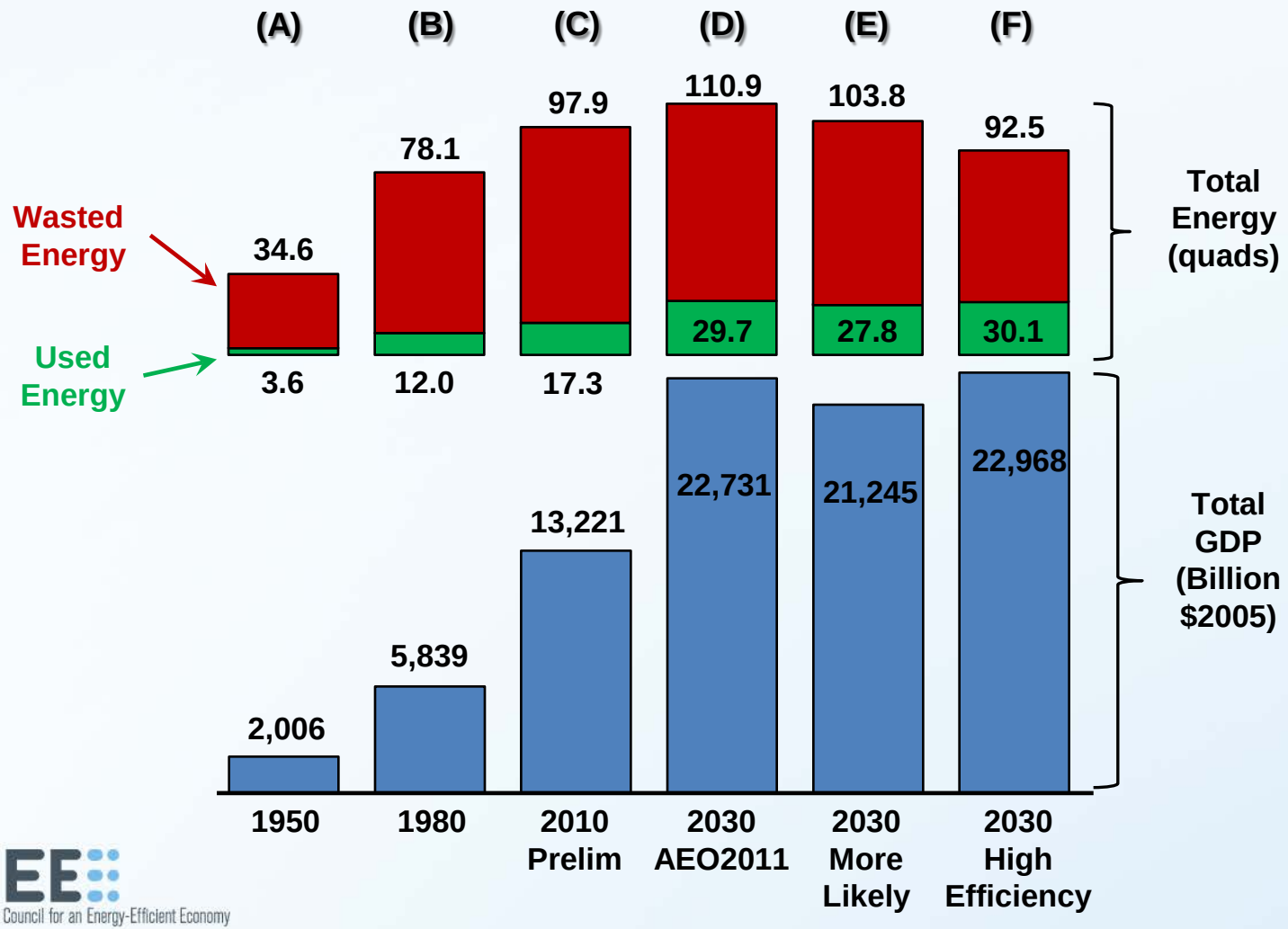
U.S. Total Energy, Used Energy, and GDP



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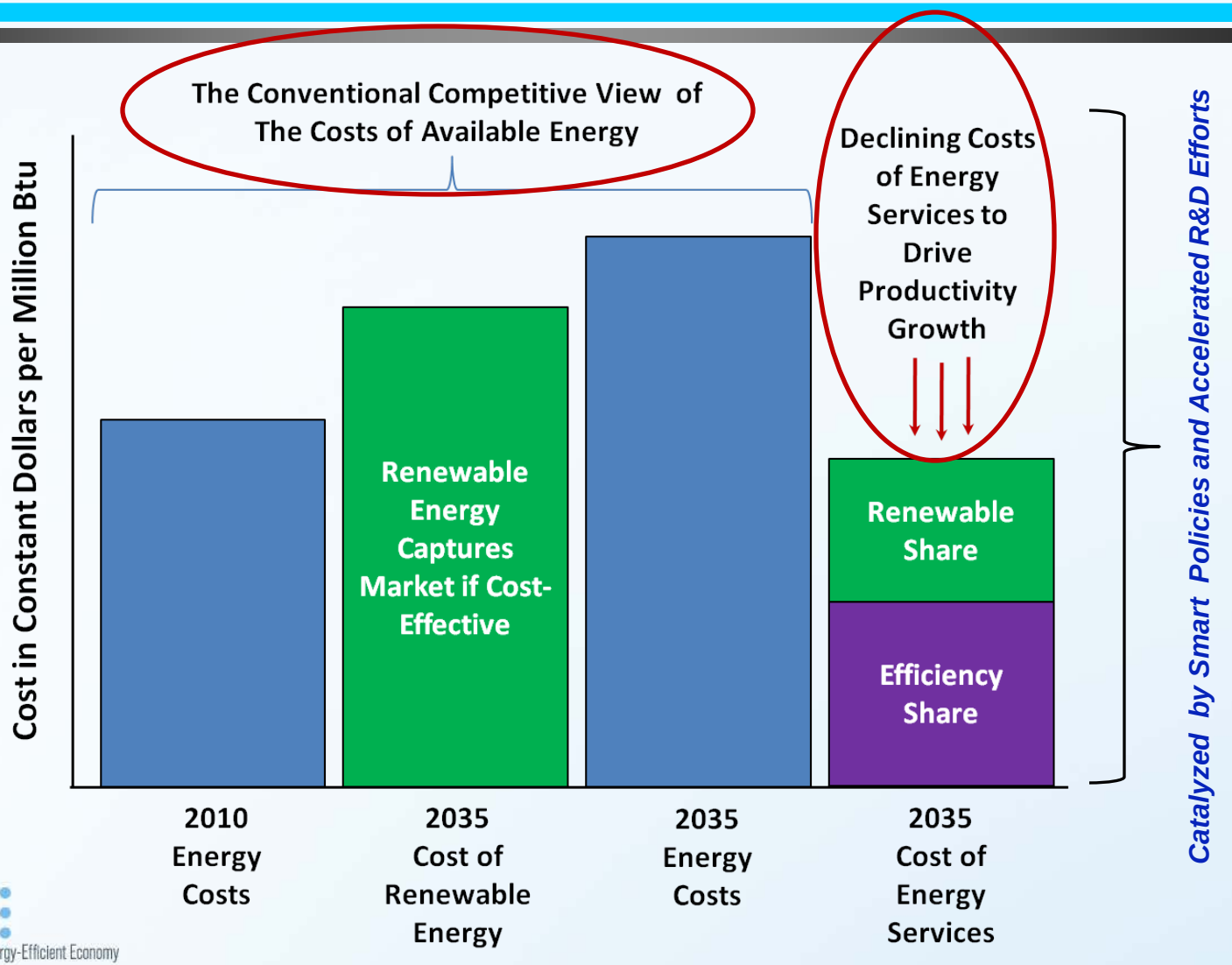
Implied Rebound Versus the Total Energy Consumed and GDP Impacts

- In the year 2030 on the previous chart, comparing the "more likely" outcome in Column E with the "high efficiency" outcome in Column F, we see the following impacts:
  - "Used Energy" Rebound = [(30.1 / 27.8) – 1] *100% = up 8.3%
  - Total Energy Consumed = [(92.5 / 103.8) – 1] *100% = down 10.9%
  - Total GDP Impacts = [(22,968 / 21,245) – 1] *100% = up 8.1%
- With these anticipated kinds of results, I recall the admonition from William Baumol and his colleagues: "For real economic miracles one must look to productivity growth." And in this case, productivity growth tied to the doubling or tripling of our existing levels of energy efficiency.

But this is more than an "energy quantity" issue, it is also an "energy cost" issue that will either limit, or that will drive, overall economic productivity. . . .

****Where "cost" refers to the full market and non-markets costs and benefits associated with the use of energy services.***

Costs of Energy Services as Driver of Productivity Growth



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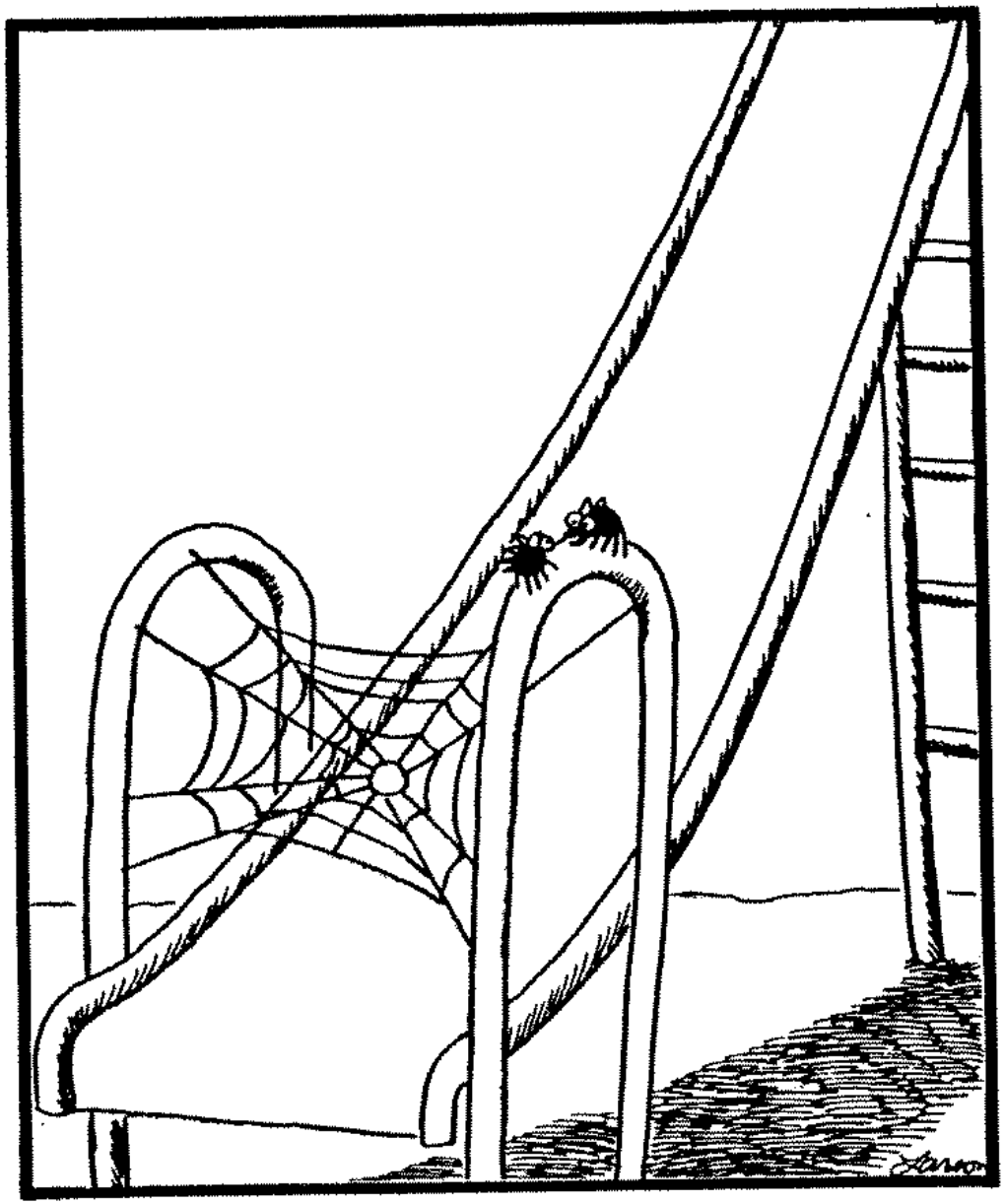

"If we pull this off, we'll eat like kings."

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